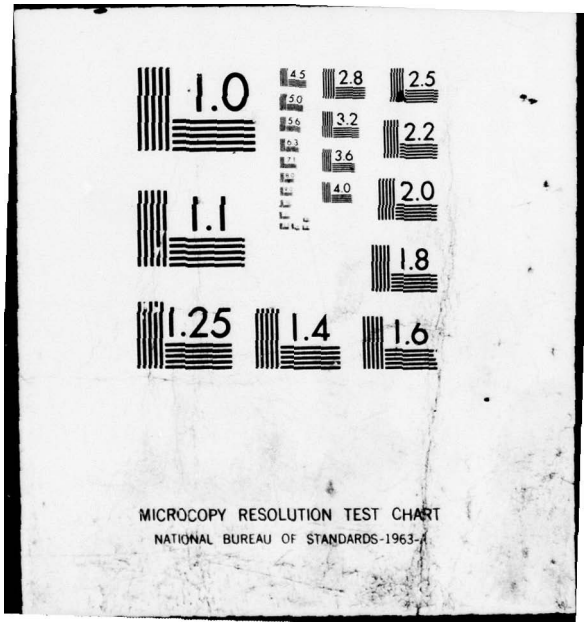
AD-A063 849 ADVISORY GROUP FOR AEROSPACE RESEARCH AND DEVELOPMENT--ETC F/G 5/1
THE AGARD PROPULSION AND ENERGETICS PANEL: 1952-1977.(U)
NOV 78 S S PENNER

UNCLASSIFIED AGARD-AR-111 NL

1 OF 1
AD A063 849

END
DATE FILMED
3-79
DDC


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0
5.6
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

AGARD-AR-111

AGARD

ADVISORY GROUP FOR AEROSPACE RESEARCH & DEVELOPMENT

7 RUE ANCELLE 92200 NEUILLY SUR SEINE FRANCE

LEVEL II

AGARD ADVISORY REPORT No. 111

The AGARD Propulsion and Energetics Panel 1952–1977

NORTH ATLANTIC TREATY ORGANIZATION

DISTRIBUTION AND AVAILABILITY
ON BACK COVER

NORTH ATLANTIC TREATY ORGANIZATION

ADVISORY GROUP FOR AEROSPACE RESEARCH AND DEVELOPMENT

(ORGANISATION DU TRAITE DE L'ATLANTIQUE NORD)

(9)
AGARD Advisory Report, No.111

(6)
THE AGARD PROPULSION AND ENERGETICS PANEL: 1952 – 1977,

by

(10) S.S. Penner
Energy Center and
Department of Applied Mechanics and Engineering Sciences
University of California, San Diego
La Jolla, California 92093

Prepared for the Propulsion and Energetics Panel of AGARD.

THE MISSION OF AGARD

The mission of AGARD is to bring together the leading personalities of the NATO nations in the fields of science and technology relating to aerospace for the following purposes:

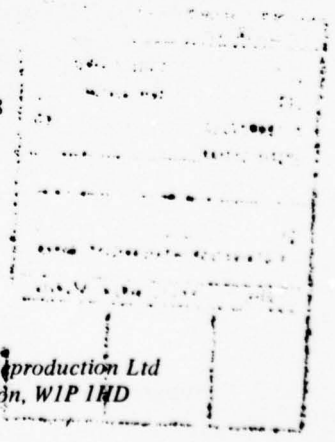
- Exchanging of scientific and technical information;
- Continuously stimulating advances in the aerospace sciences relevant to strengthening the common defence posture;
- Improving the co-operation among member nations in aerospace research and development;
- Providing scientific and technical advice and assistance to the North Atlantic Military Committee in the field of aerospace research and development;
- Rendering scientific and technical assistance, as requested, to other NATO bodies and to member nations in connection with research and development problems in the aerospace field;
- Providing assistance to member nations for the purpose of increasing their scientific and technical potential;
- Recommending effective ways for the member nations to use their research and development capabilities for the common benefit of the NATO community.

The highest authority within AGARD is the National Delegates Board consisting of officially appointed senior representatives from each member nation. The mission of AGARD is carried out through the Panels which are composed of experts appointed by the National Delegates, the Consultant and Exchange Programme and the Aerospace Applications Studies Programme. The results of AGARD work are reported to the member nations and the NATO Authorities through the AGARD series of publications of which this is one.

Participation in AGARD activities is by invitation only and is normally limited to citizens of the NATO nations.

Published November 1978

ISBN 92-835-1258-8



Set and printed by Technical Editing and Reproduction Ltd
Harford House, 7–9 Charlotte St, London, W1P 1HD

PREFACE

In 1977 the Propulsion and Energetics Panel (PEP) looked back on a 25-year history of work in several fields which are vital for aerospace technology.

During this period aerospace research and development in general has experienced vast changes of emphasis. A period of seemingly unlimited progress to new horizons characterised the first 15 years, followed by a period of growing cognizance that the resources for technical progress are limited and that problems other than aerospace suddenly attracted the public as, for example, environmental protection or the energy situation.

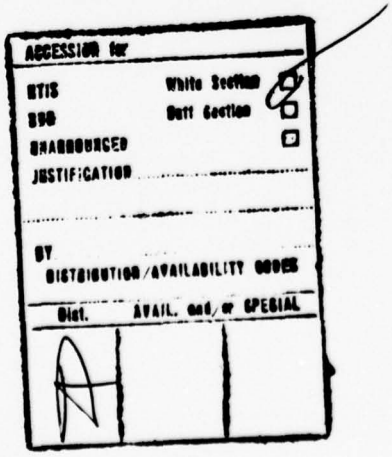
At the same time aerospace technology had grown to a certain state of maturity so that the pace of progress naturally slowed down. Also, the worldwide economic trends of rising costs and inflation opened a gap between increasing costs for procurement and operation of equipment and the available funds, both for military and civil operators of aeronautical equipment.

Therefore, it was quite natural that scientific-technical bodies such as AGARD had to react to these developments. Whereas at the beginning of PEP's activities the emphasis in the Panel's work was on basically scientific aspects, and activities were directed to long-term needs of future propulsion technology, the new situation forced the Panel to include in its scope of work also the near-term needs of existing propulsion systems. This was done also in accordance with requests of the National Delegates of AGARD. Therefore, the scope of the Panel's work broadened considerably. From the first scientific subject of combustion-research in which the Panel really played a leading role, the Terms of References have developed to the present very wide spectrum which covers also problems of hardware development as well as operational aspects.

In view of this development, the 25th anniversary of the Panel's foundation presented a good opportunity to ask whether the panel had adequately performed its role within the AGARD-community. Fortunately, it was possible to induce Professor S.S.Penner, one of the Founder Members of the Panel, to critically survey the Panel's activities. The Panel is very much indebted to Prof. Penner and expresses its sincerest thanks to him for having taken over this burden.

The following report is the result of Prof. Penner's studies, the contents of which were discussed with him during the Panel's 51st Meeting in April 1978 in London. There were, of course, points where opinions diverged; this is natural for a scientific-technical body which is composed of a large number of individuals, and which has to act according to the prescribed AGARD policy. However, the report in general represents a most valuable contribution to our Panel work. It has already stimulated discussions on future technical programs, and it will continue to do so, thus stimulating the Panel to cope with the scientific-technological challenges of the future.

Prof. Dr-Ing. G.WINTERFELD
Chairman,
Propulsion and Energetics Panel



CONTENTS

		Page
PREFACE		iii
1.	INTRODUCTION	1
2.	THE COMBUSTION PANEL: 1952–1956	2
3.	THE COMBUSTION AND PROPULSION PANEL: 1956–1964	4
4.	THE PROPULSION AND ENERGETICS PANEL: 1965–1977	6
5.	AGARDOGRAPHS	10
6.	THE AGARD PEP LECTURE SERIES PROGRAM	12
7.	TECHNICAL EVALUATION AND ADVISORY REPORTS	14
8.	PEP WORKING GROUPS	15
9.	THE CURRENT AND FUTURE ROLES OF THE AGARD PEP	16
Appendix I	PANEL MEMBERSHIP AND OFFICERS (1952–1977)	21
Appendix II	SOME SUGGESTIONS FOR SYSTEMS STUDIES RELATED TO NATO ENERGY PLANNING	26
Appendix III	PEP TERMS OF REFERENCE AND TOPICS LIST (as revised 1978)	27

THE AGARD PROPULSION AND ENERGETICS PANEL: 1952–1977

by

S.S.Penner
Energy Center and
Department of Applied Mechanics and Engineering Sciences
University of California, San Diego
La Jolla, California 92093

1. INTRODUCTION

AGARD was, in large measure, the creation of the late Theodore von Kármán.*

AGARD was created about 6 years after the conclusion of the Second World War. Aeronautical research in most of the countries of Western Europe was at the very beginnings of reconstruction and advancement. US dollars were being funneled through the Marshal plan to former friends and foes alike in a historically unprecedented effort to assist in the rebuilding. It was during these times that AGARD was conceived and implemented and what was originally called the AGARD/NATO Combustion Panel was formally established in 1952. Von Kármán had become personally involved in combustion research about one year earlier. It was his view that theoretical combustion analyses, in which the authors had attempted to utilize chemical rate processes in conjunction with the equations of fluid mechanics, had not been properly executed. Von Kármán's sense of esthetics was offended because he felt that the results of theoretical studies were not at once apparent from the inputs and often could not be explained in appealing physical terms. His standards of rigor and insight were not always met in the work published by others. The AGARD Combustion Panel began its operation with the mission to place combustion research or aerothermochemistry (these two terms were often used interchangeably) on a firm theoretical basis and to apply appropriate formulations of chemical kinetics to the solution of combustion problems. At times, von Kármán actually used more colorful language which, on the occasion of the 1952 International Combustion Symposium, precipitated lively debates that did not suggest the fundamentally high regard with which von Kármán viewed the pioneering works of Bernard Lewis and Günther von Elbe, Ya.B.Zeldovich, J.O.Hirschfelder, and others.

The official Panel name was changed in 1956 to Combustion and Propulsion Panel and in 1965 to Propulsion and Energetics Panel. The designations were modified to accommodate significant shifts in Panel efforts that reflected changes in the research activities of NATO scientists and engineers, as well as changing emphasis in the research needs of the NATO community. The occurrence of name changes on only two occasions does not properly reflect the evolutionary nature of Panel efforts. The AGARD Combustion, Combustion and Propulsion and Propulsion and Energetics Panel (hereafter referred to as PEP) has been characterized by adaptation and timely evolution, by a redefinition of primary mission objectives with the appointment of new Panel members, and by pioneering research contributions to those areas of activities that became especially pertinent to NATO Research and Development in the aeronautical and later aerospace sciences.

It will be our purpose in succeeding sections to study the intellectual contributions of the Panel and to comment on the impacts of these studies on aerospace engineering in the NATO countries, as well as on its relation to work done by the international community of experts. The intellectual contributions made by panels of experts are inextricably linked

---

* The story of the first 16 years of AGARD has been summarized in the booklet *AGARD History 1952–1968*, 143 pages, Frank L.Wattendorf ed. During the first conference of aeronautical experts from the NATO nations (Washington, D.C., February 1951), the founding delegates adopted the following resolution:

"All the Delegates agreed that in the present world situation, faced as they were with common problems of grave importance, there was an urgent need, as well as the existing potential, for working together in mobilizing to mutual advantage the scientific and technical skill, manpower and facilities of all NATO Nations."

"All Delegates were of the opinion that, without affecting the principles of national policies, it is possible to accomplish much by the exchange of information, and by the fullest use of qualified manpower and existing research and development facilities to mutual advantage. At the same time, it should be profitable to coordinate the planning of future facilities with a view to their common use."

"Much will be gained by the acceleration of research and development projects by common efforts for the common good, and also by bringing together teams of leading scientists and engineers to consider and help in the solution of problems of common defense."

In his foreword to AGARD History 1952–1968, Finn Lied of Norway (who served as AGARD Chairman in 1969) summarized his view of AGARD as follows:

"Though basically a form of international Learned Society serving NATO in a consultative capacity, AGARD is different from the well known national Learned Societies or Institutions in that it has developed, with the aid of NATO funding, a Consultant and Exchange Programme of its own for the benefit of its members."

with the innovations of individual panel members, authors, and panel executives. However, this aspect of AGARD PEP history will not be emphasized; it is, in any case, documented at various stages of Panel activities by the identities of the Panel chairmen, by the scientists and engineers responsible for arrangements of programs and plans, by conference chairmen, by AGARD-sponsored lecturers, and perhaps most importantly by the authors and editors of colloquium proceedings and other AGARD publications. Study of information compiled in Tables included in this document will provide identification of these individual contributions. Here we shall be concerned with the performance of the Panel as a whole. A complete listing of Panel members appears in Appendix I.

2. THE COMBUSTION PANEL: 1952–1956

2.1 Introduction

The initial Panel membership is listed in Table 2.1. The schedule of meetings and publications is summarized in Table 2.2. The contents of the conference publications produced during the period 1952–1956 may be ascertained by referring to the listed, commercially available books.

2.2 Comments on the Scientific and Technical Contributions Made by the Combustion Panel

The years 1952–1956 were a period of extraordinary impact of Panel activities not only on the NATO community but on combustion research in general. A number of the basic papers presented at the AGARD meetings have remained widely quoted to this day. The colloquium proceedings and AGARDographs of this period reflect the emphasis that was placed by the Panel members on interdisciplinary research, on examining in detail controversial points of view, and on emphasizing the importance of basic combustion research in the development of improved propulsion systems.

Among basic combustion studies, we note especially research on laminar, turbulent and diffusion flames, ignition phenomena both in the homogeneous phase and in laminar mixing layers, combustion spectroscopy, burning mechanisms of double-base and composite solid propellants, burning of single droplets, droplet arrays and sprays, flame stabilization, spontaneous ignition, the mechanism of carbon formation, transport phenomena, and similarity parameters in combustion. Coupled with these fundamental studies were such investigations as low-pressure (i.e., high altitude) burning, analyses of combustion phenomena in pulse-jets, rocket-engine scaling, ramjet-combustion phenomena, etc.

Some of the cited contributions were controversial when they were first presented, some have become accepted as milestones in the field, all had an immediate impact on active workers and on subsequent research.

Fundamental studies were coupled from the beginning with more applied work that served either as a synthetic summary statement of past achievements or else provided the impetus for important new initiatives.

Some insight on the impact of the cited and other contributions may be obtained by examining the discussions following the colloquium presentations, which are printed in the original publications. Another type of evaluation is provided by numerous references in the papers presented at the International Combustion Symposia and the combustion journals to AGARD publications.

2.3 Impact on NATO Research and Development

The primary effect of the activities of the AGARD Combustion Panel was the symbiotic development of numerous combustion-research centers in conjunction with the major aeronautical and propulsion research laboratories of the NATO countries. During 1952, the colloquium contributions were dominated by US workers with major participation also from the UK and France. By 1956, the educational process, which had been defined to be a cornerstone of initial AGARD Panel objectives, had already progressed to the point of creating major research centers in most of the NATO countries.

The diffusion and evolution of combustion research was accomplished in many ways. The colloquia, panel meetings, colloquium publications, and AGARDographs constituted important facets. Personal contacts, lectures throughout the NATO countries, pre-doctoral and post-doctoral exchanges, and prolonged visits by senior investigators were perhaps even more important over the long term. Von Kármán's enormous prestige, interest, active participation, and personal contributions played a major role in assuring almost immediate and widespread acceptance of Panel initiatives. Studies of the basic equations of aerothermochemistry became integrated into the aeronautics curricula taught at major universities everywhere. Courses dealing with the elements of rocket propulsion were made more scientific and ultimately more useful.

A major development problem during the fifties dealt with rocket-engine scaling and with the construction of stably and reliably operating liquid- and solid-fuel rockets of progressively larger sizes. The early and effective involvement of the Panel in these fields provided one of the primary motivations for renaming the Panel in recognition of the larger mission which it had properly assumed almost from the very beginning.

TABLE 2.1

Founding Members of the AGARD Combustion Panel, 1952

Country	*Panel Member(s)*	*Organizational Affiliation*
Belgium	J.Ducarme (3rd Panel Chairman)	Université de Liège and Service Technique de l'Aéronautique
Canada	J.W.Broughton	National Research Council, Ottawa
France	J.Fabri (5th Panel Chairman)	ONERA, Châtillon-sous-Bagneux
	J.Lamy	Centre d'Essais des Moteurs et Hélices, Saclay
	J.Surugue (1st Panel Chairman)	ONERA, Châtillon-sous-Bagneux
Italy	E.Mancini	Fiat, Turin
Netherlands	G.Zwikker	NLR, Amsterdam
Norway	R.Hveding	NDRE, Kjeller
United Kingdom	B.P.Mullins (2nd Panel Chairman)	NGTE, Pyestock
USA	F.E.Marble	California Institute of Technology, Pasadena, California
	S.S.Penner (4th Panel Chairman)	California Institute of Technology, Pasadena, California

TABLE 2.2

Meetings and Publications of the AGARD Combustion Panel, 1952–1956

Panel Meeting	*Location*	*Activities and Publication(s)*
1st, September 1952	Cambridge, Mass., USA	Inaugural Panel business; participation in the 4th International Combustion Symposium; no Panel publication
2nd, December 1952	Rome, Italy	Participation in the AGARD General Assembly; Panel business meeting, also Panel technical sessions devoted to surveys of problems in the aerothermochemistry of combustion. 1st Combustion Seminar. AG 5/P2 – *Technical Presentations before the AGARD Combustion Panel*, Category II,* printed by the USAF.
3rd, February 1953	Paris, France	Business meeting only.
4th, September 1953	London, UK	Business meeting only.
5th, December 1953 (1st Colloquium)	Cambridge, UK	1st Combustion Colloquium. Business and technical meeting. Colloquium Committee: J.V.Charyk, J.Fabri, W.R.Hawthorne, S.S.Penner, and J.Surugue. *Selected Combustion Problems – Fundamentals and Aeronautical Applications*, Eds. W.R.Hawthorne and J.Fabri, Asst. Ed. D.B.Spalding; Category I,† Butterworths Scientific Publications, London, 1954.
6th, May 1954	Scheveningen, Netherlands	Participation in the 4th AGARD General Assembly and technical presentations (2nd Combustion Seminar) AGARDograph 9 – *Combustion Researches and Reviews* Ed. B.P.Mullins, Category I, Butterworths Scientific Publications, London 1955 (including papers presented at the 7th Meeting).
7th, November 1954	Paris, France	Technical presentations (3rd Combustion Seminar) and extended Business Meeting.

(Continued)

* Category II = soft cover books, distribution see back of this copy.

† Category I = hard cover books, commercially available.

TABLE 2.2 (continued)

Panel Meeting	*Location*	*Activities and Publication(s)*
8th, June 1955	Baltimore, Md., USA and Ottawa, Canada	Participation in USAF ARDC seminar on "The Role of Chemistry in Combustion" and in the 5th AGARD General Assembly. Business meeting. No Panel publication.
9th, December 1955	Liège, Belgium	2nd AGARD Combustion Colloquium. *Selected Combustion Problems II. Transport Phenomena; Ignition; Altitude Behaviour and Scaling of Aeroengines*, Sr. Ed. M.W.Thring, Eds. J.Ducarme and J.Fabri, Asst. Ed. P.H.Price, Category I, Butterworth Scientific Publications, London, 1956.
10th, May 1956	Oslo, Norway	Technical presentations (4th Combustion Seminar) and Business meeting. AGARDograph 15 – *Combustion Researches and Reviews 1957*, Sr. Ed. B.P.Mullins, Ed. J.Fabri, Category I, Butterworths Scientific Publications, London, 1957.

3. THE COMBUSTION AND PROPULSION PANEL: 1956–1964

3.1 Introduction

The initial Panel-member roster is listed in Table 3.1. The schedule of meetings and publications is summarized in Table 3.2. The content of the conference publications produced during the period 1954–1964 may be ascertained by referring to the appropriate commercial publications.

3.2 Comments on the Scientific and Technical Contributions Made by the Combustion and Propulsion Panel

Although engine-development problems, especially those arising in rocket-engine construction, had been studied by the antecedent Panel since its inception, it was not until 1956 that the Panel organized a Colloquium dealing exclusively with air-breathing propulsion systems.

By the end of 1964, specialists conferences had been organized in each of the following topical areas: pulse-jets, air-intake problems in supersonic combustion, powerplant requirements relating to aircraft (including discussions of test facilities, engine-component testing, flight-test problems), propellants for liquid-fuel and solid-fuel rockets and for air-breathing engines, high-Mach-number air-breathing engines (including hypersonic ramjets, research in turbomachinery, and high-temperature materials problems), advanced propulsion techniques (including nuclear, ion and magnetofluid-dynamic propulsion), V/STOL aircraft, and materials problems relating to the developments of high-temperature plastics for use in solid propellants and ablation during atmospheric entry. Concurrently with these propulsion-oriented studies, active work was continued on all aspects of combustion research. Distinguished publications will be found on such specialized topics as hydrogen-halogen flames, shock-tube studies of relaxation processes, decomposition mechanisms of solid propellants, radiation gasdynamics, nozzle flows with chemical reactions, diffusion flames, detonation waves, atomization processes, two-phase flows, high-temperature thermochemical equilibria, transport properties in ionized gases, etc.

3.3 Impact on NATO Research and Development

During the period 1956–1964, the Panel assumed its proper role as a propulsion-oriented advisory group to the NATO aerospace industry without, however, reliquishing its preeminent position in fostering interdisciplinary, combustion-related studies on those topics that bear on engine performance. The educational function of the Panel continued to be supported by vigorous lecture and exchange programs and by the publication of high-quality AGARDographs (hard-cover books) that were offered for public sale. Von Kármán's active involvement in Panel activities continued until shortly before his death in May 1963.

During the eight-year period of operation of the Combustion and Propulsion Panel, significant progress was also made in establishing excellent working relations with the NATO military groups, thereby assuring that Panel activities were both pertinent and more immediately useful to these user organizations.

By 1964, the ravages of war on the European aerospace industry had been healed. The Panel members from the NATO countries met as equals in a community of scholars. For reasons that were unrelated to the current "energy crisis", the Panel organized a colloquium on the subjects of energy sources and energy conversion. The Sixth Colloquium of the AGARD Combustion and Propulsion Panel was organized in 1964 primarily for the purpose of dealing with energy-conversion studies relating to space missions (while including such diverse topics as cycle analyses; solar collectors;

nuclear energy sources; thermionic, MHD, EFD, and thermoelectric converters; fuel cells and batteries; photovoltaic devices). However, the importance and potential impact of studies of this type was at once recognized by the Panel members and led to the almost immediate recommendation that the Panel change its official name to Propulsion and Energetics Panel. This change became effective in 1965, eight years before the importance of energy-supply sources to the economic well-being of the NATO countries was generally recognized. Deletion of the combustion label had more than symbolic significance, as we shall see. On the other hand, serious Panel involvement in "Energetics" in the broad sense and major contributions to this field appear to be only now under consideration by the PEP. We shall return to this topic in our recommendations for future work (Section 9).

TABLE 3.1

Members of the AGARD Combustion and Propulsion Panel in 1956

Country	*Panel Member(s)*	*Organizational Affiliation*
Belgium	J.Ducarme	Université de Liège and Service Technique de l'Aéronautique
Canada	J.W.Broughton	National Research Council, Ottawa
Denmark	K.Refslund	Technical University, Lyngby, Copenhagen
France	J.Fabri	ONERA, Châtillon-sous-Bagneux
	J.Surugue	ONERA, Châtillon-sous-Bagneux
	A.Vialette	Service Technique Aéronautique, Paris
Germany	W.Jost	University of Göttingen, Göttingen
	O.Lutz (6th Panel Chairman)	Technische Hochschule and DFVLR, Braunschweig
Greece	A.Lambrou	State Armament Factory, Athens
Italy	A.Capetti	Politecnico di Torino, Torino
Netherlands	G.Zwikker	NLR, Amsterdam
Norway	O.Blichner	Norwegian Defence Research Establishment, Kjeller
United Kingdom	B.P.Mullins	NGTE, Pyestock
	W.G.S.Parker	RPD, RAE, Westcott
USA	M.Gerstein	NACA, Cleveland, Ohio
	F.E.Marble	California Institute of Technology, Pasadena, California
	S.S.Penner	California Institute of Technology, Pasadena, California
	A.M.Rothrock	NACA, Washington, D.C.

TABLE 3.2

Meetings and Publications of the AGARD Combustion and Propulsion Panel, 1956–1964

Panel Meeting	*Location*	*Activities and Publication(s)*
11th, December 1956	Paris, France	AGARDograph 27 – *Air Intake Problems in Supersonic Combustion*, Ed. J.Fabri, Category I, Pergamon Press, London, 1958.
12th, November 1957	Washington, D.C., USA	Participation in the 7th AGARD General Assembly; Panel technical sessions on Flame Stabilization, Applicability of Kinetic Data to Engine Combustion, etc. No Panel publication.
13th, March 1958 (3rd Colloquium)	Palermo, Italy	Colloquium Committee: J.Ducarme and S.S.Penner. *Combustion and Propulsion. Third AGARD Colloquium. Noise – Shock Tubes – Magnetic Effects – Instability and Mixing*, Eds. M.W.Thring, O.Lutz, J.Fabri, and A.H.Lefebvre, Category I, Pergamon Press, London, 1958.

(Continued)

TABLE 3.2 (continued)

Panel Meeting	*Location*	*Activities and Publication(s)*
14th, October 1958	Copenhagen, Denmark	Joint meeting with the Wind Tunnel and Flight Test Panels; participation in the 8th AGARD General Assembly. AGARDograph 37 – *Advanced Aero Engine Testing*, Eds. A.W.Morley and J.Fabri, Category I, Pergamon Press, London, 1959.
15th, June 1959	Paris, France	Program Committee Chairman, S.S.Penner. *The Chemistry of Propellants*, Eds. S.S.Penner and J.Ducarme, Category I, Pergamon Press, London, 1959.
16th, September 1959	Aachen, Germany	Participation in the 9th AGARD General Assembly and Panel business meeting only. No Panel publication.
17th, April 1960 (4th Colloquium)	Milan, Italy	*Combustion and Propulsion. Fourth AGARD Colloquium. High Mach Number Air-Breathing Engines*, Eds. A.L.Jaumotte, A.H.Lefebvre and A.M.Rothrock, Category I, Pergamon Press, London, 1961.
18th, August 1960	Pasadena, California USA	Program Committee Chairman, S.S.Penner. *Advanced Propulsion Techniques*, Ed. S.S.Penner, Category I, Pergamon Press, London, 1961.
19th, February 1961	Paris, France	Classified meeting on "Solid Propellant Rocketry". No Panel publication.
20th, April 1962 (5th Colloquium)	Brunswick, Germany	Combustion and Propulsion. Fifth AGARD Colloquium. *High Temperature Phenomena*, Eds. R.P.Hagerty, A.L.Jaumotte, O.Lutz and S.S.Penner, Category I, Pergamon Press, London, 1963.
21st, April 1963	London, UK	Program Committee Chairmen, A.Ferri and S.S.Penner. *Supersonic Flow, Chemical Processes and Radiative Transfer*, Eds. D.B.Olfe and V.Zakkay, Category I, Pergamon Press, London, 1964.
22nd, July 1963	Athens, Greece	Participation in the 13th General Assembly. Program Committee Chairmen, J.Fabri and F.E.Marble. AGARDograph 88 – *Physics and Technology of Ion Motors*, Eds. F.E.Marble and J.Surugue, Category I, Gordon and Breach Science Publishers, New York, 1966.
23rd, March 1964 (6th Colloquium)	Cannes, France	Program Committee Chairman, T.F.Nagey. AGARDograph 81 – *Combustion and Propulsion. Sixth AGARD Colloquium. Energy Sources and Energy Conversion*, Eds. H.M.DeGroff, R.F.Hoglund, J.Fabri, T.F.Nagey, and M.E.Rambaugh, Jr, Category I, Gordon and Breach Science Publishers, New York, 1967.
24th, September 1964	Paris, France	Program Committee Chairman, O.Lutz. AGARDograph 89 – *V/STOL Aircraft*, Category II. In two parts – Part I Unclassified, Part II Classified, 1964.

4. THE PROPULSION AND ENERGETICS PANEL: 1965–1977

4.1 Introduction

The initial roster of Panel members is listed in Table 4.1. The schedule of meetings and publications is summarized in Table 4.2. The contents of the conference publications produced since 1965 may be found either in "AGARD Index of Publications" or in the "NASA Quarterly Listing of AGARD Reports" contained in the NASA Abstract Journal "Scientific and Technical Aerospace Reports" (STAR).

TABLE 4.1

Members of the AGARD Propulsion and Energetics Panel in 1965

Country	*Panel Member(s)*	*Organizational Affiliation*
Belgium	I.Ducarme	Université de Liège and Service Technique de l'Aéronautique
	A.L.Jaumotte	Université Libre de Bruxelles
	E.Tits	Ecole Royale Militaire, Bruxelles
Canada	I.R.Cameron	CARDE, Quebec
	D.H.E.Cross	DRB and Department of Industry, Ottawa
	R.Sandri	NRC, Ottawa
	R.B.Whyte	NRC, Ottawa
Denmark	K.Refslund	Technical University, Lyngby, Copenhagen
France	P.Colombani	SNECMA, Paris and Blanquefort
	R.Dubarry-Barbe	Centre d'Essais des Propulseurs, Saclay
	J.Fabri	ONERA, Châtillon-sous-Bagneux
	M.Pianko (12th Panel Chairman)	Service Technique Aéronautique, Paris
	J.Surugue	ONERA, Châtillon-sous-Bagneux
Germany	O.Lutz	Technische Hochschule and DFVLR, Braunschweig
	P.Ruden	Industrieanlagen Betriebsgesellschaft GmbH, Munich
Greece	T.Houlis	Holargos, Athens
	A.Lambrou	State Armament Factory, Old Phaleron, Athens
Italy	A.Capetti	Politecnico di Torino, Turin
	C.Casci (7th Panel Chairman)	CNPM, Politecnico di Milano, Milano
	L.Giorgieri	Ministero della Difesa Aeronautica, Roma
	G.Maoli	FIAT, Torino
Netherlands	N.Feis	NLR, Amsterdam
Norway	T.Krog	NDRE, Kjeller
Turkey	H.Sezgen	Middle East Technical University, Ankara
United Kingdom	R.P.Hagerty	Rocket Propulsion Establishment, Westcott
	R.R.Jamison	Bristol Siddeley Engines, Ltd.
USA	P.G.Atkinson, Jr	Aerospace Research Laboratory, Wright-Patterson AFB, Dayton, Ohio
	A.Ferri (8th Panel Chairman)	Polytechnic Institute of Brooklyn, Brooklyn, New York
	I.Glassman (10th Panel Chairman)	Princeton University, Princeton, New Jersey
	T.F.Nagey	General Motors Corp., Allison Division, Warren, Michigan
	S.S.Penner	University of California, San Diego, La Jolla, California
	D.D.Weidhuner	Department of the Army, Washington, D.C.

4.2 Comments on the Scientific and Technical Contributions Made by the Propulsion and Energetics Panel, PEP (1965–1977)

During the years 1965–1977, increasing emphasis was placed on studies relating to gas-turbine propulsion. New concepts for civil and military propulsion systems were being considered. These included the high-bypass-ratio fan engine, vertical lift engines, lift-cruise engines, etc., which posed new and severe problems requiring immediate solutions. As in the past, the Panel reacted to these new challenges by stimulating the exchange of research and development results. The first full meeting on gas turbines which was held during April 1966 in Paris, marked the onset of these activities. During the following years, additional meetings were organized, including work on helicopter-propulsion systems, advanced

components for turbojet engines, and high-temperature turbines, as well as V/STOL propulsion systems, power-plant controls for aero-gas-turbine engines and, more recently, variable geometry and multicycle engines. These typical meetings on engines, engine components, and total systems were supported by increased activity in appropriate fields of applied research. Supporting research was evaluated in conference on advances in aerothermochemistry, fundamental studies of ions and plasmas, static energy conversion devices, reactions between gases and solids, energetics for auxiliary aircraft power systems, atmospheric pollution by aircraft engines, analytical and numerical methods for investigations of flow fields with chemical reactions especially related to combustion, and unsteady phenomena and secondary flows in turbomachinery.

TABLE 4.2

Meetings and Publications of the AGARD Propulsion and Energetics Panel, 1966–1976

Panel Meeting	*Location*	*Activities and Publication(s)*
25th, April 1965	La Jolla, California, USA	Program Committee Chairman, S.S.Penner. AGARD Conference Proceedings 1 – *Advances in Tactical Rocket Propulsion*, Ed. S.S.Penner, Category I, Technivision Services, Maidenhead, England, 1968.
26th, September 1965	Pisa, Italy	Program Committee Chairman, T.F.Nagey. AGARD Conference Proceedings 8 – *Fundamental Studies of Ions and Plasmas*, Ed. H.D.Wilsted, Category II (in two volumes), 1965.
27th, April 1966	Paris, France	Program Committee Chairman, A.Ferri. AGARD Conference Proceedings 9 – *Gas Turbines*, Category II (in two parts – Part I Unclassified, Part II Classified); AGARD Advisory Report 3 (Classified), 1966.
28th, May 1966 (7th Colloquium)	Oslo, Norway	Joint meeting with Fluid Dynamics Panel; Program Committee Chairman, I.Glassman. AGARD Conference Proceedings 12 – *Recent Advances in Aerothermochemistry*, Category II (in two volumes), 1966.
August 1966	Delft, Netherlands	Participation in the 2nd AGARD Annual meeting and Panel business meeting only.
29th, June 1967	Liège, Belgium	Program Committee Chairman, P.G.Atkinson, Jr. *Performance Forecast of Selected Static Energy Conversion Devices*, Category II, produced by AFAPL and ARL (OAR), Wright-Patterson Air Force Base, 1967. (Nominally AGARD Conference Proceedings 21.)
30th, September 1967	Munich, Germany	Program Committee Chairman, J.Surugue. AGARD Conference Proceedings 38 – *New Experimental Techniques in Propulsion and Energetics Research*, Eds. D.Andrews and J.Surugue, Category I, Technivision Services, Maidenhead, England, 1970.
31st, June 1968	Ottawa, Canada	Program Committee Chairman, D.D.Weidhuner. AGARD Conference Proceedings 31 – *Helicopter Propulsion Systems*, Category II, 1968.
32nd, September 1968	Toulouse, France	Program Committee Chairman, T.F.Nagey. AGARD Conference Proceedings 34 – *Advanced Components for Turbojet Engines*, Category II, (in two volumes), 1968.
33rd, May 1969	Saint-Louis, France	Joint meeting with the Fluid Dynamics Panel; Program Committee Chairmen, A.Auriol and C.T.Hewson. AGARD Conference Proceedings 42 – *Aircraft Engine Noise and Sonic Boom*, Category II, AGARD Advisory Reports 22 and 26, Category II, 1970.
34th, October 1969 (8th Colloquium)	Dayton, Ohio, USA	Colloquium Committee Chairman, P.G.Atkinson, Jr. AGARD Conference Proceedings 52 – *Reactions between Gases and Solids*, Category II, 1970, and AGARD Advisory Report 32, Category II, 1971.
35th, April 1970	London, UK	Program Committee Chairman, A.E.Fuhs. AGARD Conference Proceedings 64 – *Advanced Technology for Production of Aerospace Engines*, Category II, 1970.

(Continued)

TABLE 4.2 (continued)

Panel Meeting	*Location*	*Activities and Publication(s)*
36th, September 1970	Florence, Italy	Program Committee Chairman, M.Pianko. AGARD Conference Proceedings 73 – *High Temperature Turbines*, Category II, 1971; AGARD Advisory Report 29, Category II, 1971.
37th, May 1971	The Hague, Netherlands	Program Committee Chairman, D.Dini. AGARD Conference Proceedings 84 – *Aircraft Fuels, Lubricants, and Fire Safety*. Category II, 1971; AGARD Advisory Report 44, Category II, 1972.
38th, September 1971	Sandefjord, Norway	Program Committee Chairman, N.F.Rekos. AGARD Conference Proceedings 91 – *Inlets and Nozzles for Aerospace Engines*, Category II, 1971; AGARD Advisory Report 41, Category II, 1972.
39th, June 1972	Colorado Springs, Colorado, USA	Program Committee Chairman, A.E.Fuhs. AGARD Conference Proceedings 104 – *Energetics for Aircraft Auxiliary Power Systems*, Category II, 1972; AGARD Advisory Report 50, Category II, 1972.
40th, September 1972 (jointly with SMP)	Toulouse, France	Program Committee Chairmen, N.E.Promisel and R.J.Lane. AGARD Conference Proceedings 112 – *Impact of Composite Materials on Aerospace Vehicles and Propulsion Systems*, Category II, 1972.
41st, April 1973	London, UK	Program Committee Chairman, A.Ferri. AGARD Conference Proceedings 125 – *Atmospheric Pollution by Aircraft Engines*, Category II, 1973; AGARD Advisory Report 63, 1973.
42nd, September 1973	Schliersee, Germany	Program Committee Chairman, N.F.Rekos. AGARD Conference Proceedings 135 – *V/STOL Propulsion Systems*, Category II, 1973; AGARD Advisory Report 64, 1974.
43rd, April 1974	Liège, Belgium	Two Specialists Meetings. Program Committee Chairman, M.L.Barrère, AGARD Conference Proceedings 164 – *Analytical and Numerical Methods for Investigation of Flow Fields with Chemical Reactions, Especially Related to Combustion*, Category II, 1975; Program Committee Chairman, A.E.Fuhs, AGARD Conference Proceedings 1965 – *Diagnostics and Engine Condition Monitoring*, Category II, 1975.
44th, September 1974	Ustaoset, Norway	Program Committee Chairman, N.K.H.Scholz. AGARD Conference Proceedings 151 – *Power Plant Controls for Aero-Gas Turbine Engines*, Category II, 1975.
45th, April 1975	Rome, Italy	Program Committee Chairman, I.Glassman. AGARD Conference Proceedings 166 – *Aircraft Fire Safety*, Category II, 1975.
46th, September 1975	Monterey, California, USA	Program Committee Chairman, J.Dunham. AGARD Conference Proceedings 177 – *Unsteady Phenomena in Turbomachinery*, Category II, 1976.
47th, May 1976	Köln, Germany	Two Specialists Meetings. Program Committee Chairman, G.Winterfeld, AGARD Conference Proceedings 194 – *Small Solid Propellant Rockets for Field Use*, Category II, 1976. Program Committee Chairman, J.Chauvin, AGARD Conference Proceedings 195 – *Through-flow Calculations in Axial Turbomachinery*, Category II, 1976.
48th, September 1976	Paris, France	Program Committee Chairman, N.F.Rekos. AGARD Conference Proceedings 205 – *Variable Geometry and Multi-cycle Engines*, Category II, 1976.

Research and development for propulsion systems is a highly interdisciplinary subject and the Panel has emphasized the relation to propulsion of different specialties. Meetings such as those on the impact of composite materials on aerospace vehicles and propulsion systems, inlets and nozzles for aerospace engines, aircraft fuels, lubricants and fire safety,

engine noise and sonic boom, and aircraft fire safety mark the Panel's accomplishments in these fields. In recent years, operational problems of aero-engines have become more and more important for military and civilian operators. In response to these needs, the Panel also held specialists' meetings and working groups on diagnostics and engine-condition monitoring, power plant reliability, engine deterioration, etc.

Because the primary focus of PEP activities related to vehicles and complete systems, fundamental combustion studies and work in the broad areas of energetics received less emphasis. In terms of combustion-related studies, we may note a 1966 summary of advances in aerothermochemistry, a 1969 conference on reactions between gases and solids, and a 1974 specialists' meeting on numerical methods in the solution of combustion problems. The PEP contributions to fundamental combustion research during the years 1965–1977 were thus not extensive, its role as a major forum having been taken over by the Combustion Symposia organized by the international Combustion Institute.

Contributions to the broad area of energetics were made by the following studies: performance forecasts for batteries, fuel cells and solar cells (1967); aircraft fuels, lubricants and fire safety were evaluated in 1971 and auxiliary power systems during 1972; atmospheric pollution by aircraft engines was examined in 1973.

4.3 Impact on NATO Research and Development

We have noted that the propulsion mission has been emphasized during the years 1965–1977. There can be no doubt that this emphasis is well justified in terms of requirements by the NATO aerospace industries and in terms of the needs of the military sponsors of AGARD who are ultimately both the funding agency and the primary recipients of Panel outputs.

The shift in emphasis to applied propulsion development, coupled with the decision by AGARD to terminate publication of hard cover books for economy reasons and the replacement of hard cover books by Category II publications (soft cover, not for public sale), has made the AGARD PEP less visible than its antecedents, at least in some of the NATO countries.

5. AGARDOGRAPHS

At the second meeting in 1952, the Panel first considered the commissioning of selected monographs relating to important areas of Panel activities. These monographs were named AGARDographs and are listed in Tables 5.1 to 5.3. They were designed to provide tutorial summaries of fields of study that were deemed to be especially pertinent to active workers in the NATO countries in developing areas of research. The first two of these commissioned by the Combustion Panel were published in 1955 as AGARDographs Nos. 4 and 7 and dealt with spontaneous ignition of liquid fuels and chemical reactions in flow systems, respectively (see Table 5.1). The preparation of AGARDograph No.47 is noteworthy because the author was funded to visit major research centers in Europe and the US in order to prepare an authoritative contribution. Pioneering work on rocket-motor instability (AGARDograph No.8) has remained a classic in the field. The methodologies described in AGARDographs 4 and 7 have been widely adopted. There is, for example, a remarkable similarity with respect to the methods of analysis, notation, and physical contents with current studies of related topics.* What was accomplished during the early fifties was the approximate solution of a host of basic problems. Refinements of these studies constitute a major component of current combustion research. A kind observation on these developments corresponds to the view that the easy jobs were done during the fifties while the difficult improvements are now in progress; an unkind statement would be the following: the essential features of the problems were defined by the early workers leaving the crossing of *t*s and dotting of *i*s to their followers. According to his tastes, the reader should form his own judgements. What is, however, undeniably true is that the AGARDographs sponsored and initiated by the AGARD Combustion Panel have exerted a profound effect on subsequent research. In this connection, synthetic summaries of nonsteady flame propagation (AGARDograph No.75), solid-propellants (No.116), chemical propellants (No.129), and instrumentation (Nos. 96 and 130) deserve special mention.

The multi-author (see Table 5.2) as well as the soft-cover AGARDographs (Table 5.3) deal with important topical studies. The more recent, propulsion-oriented publications are especially important to the NATO user groups. It is indeed unfortunate that these Category II books have had only limited distribution. It should be noted that most of these are still obtainable through AGARD National Distribution Centers.†

---

* Compare, for example, the treatment of droplet burning appearing on pp.68-81 of AGARDograph No.7 and the corresponding treatment by A.Williams, Progress in Energy and Combustion Science 2, 167 (1976).

† Interested readers should refer to the back cover of this report for details concerning locations of desired publications within the various NATO countries. For more specific questions the reader should contact the PEP Executive at AGARD.

TABLE 5.1

AGARDographs (Hard-Cover Books) Sponsored by the Combustion, Combustion and Propulsion and the Propulsion and Energetics Panel, 1952–1976

AGARDograph Number	*Author(s)*	*Title*	*Publisher and Date of Publication*
4	B.P.Mullins	*Spontaneous Ignition of Liquid Fuels*, 117 pages	Butterworths Scientific Publications, London, 1955
7	S.S.Penner	*Introduction to the Study of Chemical Reactions in Flow Systems*, 86 pages	Butterworths Scientific Publications, London, 1955
8	L.Crocco and S.-I.Cheng	*Theory of Combustion Instability in Liquid Propellant Rocket Motors*, 200 pages	Butterworths Scientific Publications, London, 1956
31	S.S.Penner and B.P.Mullins	*Explosions, Detonations, Flammability and Ignition*, 287 pages	Pergamon Press, Ltd., London, 1959
47	G.Tiné	*Gas Sampling and Chemical Analysis in Combustion Processes*, 94 pages	Pergamon Press, Ltd., London, 1961
75	G.H.Markstein	*Nonsteady Flame Propagation*, 328 pages	Pergamon Press Ltd., London, 1964
96	A.E.Fuhs	*Instrumentation for High Speed Plasma Flow*, 180 pages	Gordon and Breach Science Publishers, New York, 1965
116	F.A.Williams, M.Barrère and N.C.Huang	*Fundamental Aspects of Solid Propellant Rockets*, 791 pages	Technivision Services, Slough, England, 1969
129	I.Glassman and R.F.Sawyer	*The Performance of Chemical Propellants*, 143 pages	Technivision Services, Slough, England, 1969
130	E.R.G.Eckert and R.J.Goldstein	*Measurement Techniques in Heat Transfer*, 522 pages	Technivision Services, Slough, England, 1970

TABLE 5.2

Multiauthor AGARDographs (Hard-Cover Books) Sponsored by the AGARD Combustion, Combustion and Propulsion, or Propulsion and Energetics Panel, 1952–1977

AGARDograph Number	*Editor*	*Title*	*Publisher and Date of Publication*
41	A.Ferri	*Fundamental Data Obtained from Shock-Tube Experiments*, 415 pages	Pergamon Press, Ltd., London, 1961
–*	J.Surugue	*Experimental Methods in Combustion Research, (Manual)* 708 pages	Pergamon Press, Ltd., London, 1961, 1964
86	W.Jost	*Low Temperature Oxidation*, 412 pages	Gordon and Breach Science Publishers, New York, 1965
120	J.Chauvin	*Supersonic Turbo-Jet Propulsion Systems and Components*, 474 pages	Technivision Services, Slough, England, 1969

* Early AGARD internal code: MN4.

TABLE 5.3

AGARDographs (Soft-Cover Books, not for Sale) Sponsored by the AGARD Combustion, Combustion and Propulsion, or Propulsion and Energetics Panel, 1952–1976

AGARDograph Number	*Author(s) or Editor(s)*	*Title*
98	O.Lutz and G.Stoffers	*Graphical Methods in Aerodynamics*, 302 pages, 1967.
108	G.J.Souilhard, J.Ducarme and T.H. de Menten de Horne	*Combustibles, Lubrifiants et Fluides Auxiliaires pour l'Aviation Supersonique*, 308 pages, 1970.
117	L.Crocco and W.A.Sirignano	*Behaviour of Supercritical Nozzles under Three-Dimensional Oscillatory Conditions*, 149 pages, 1967.
– *	R.W.McIntyre, Ed.	*Properties of Air and Combustion Products with Kerosine and Hydrogen Fuels*, 13 volumes, 1967.
122	M.Lawson and F.Wattendorf, Eds.	*Selected Topics in Electrofluid Dynamic Energy Conversion*, 262 pages, 1968.
141	P.Tavernier, J.Boisson and B.Crampel	*Propergols Hautement Energétiques*, 336 pages, 1970.
148	H.Ziebland and R.C.Parkinson	*Heat Transfer in Rocket Engines*, 154 pages, 1971.
164	J.Surugue, Ed.	*Boundary Layer Effects in Turbomachines*, 473 pages, 1972.
167	M.Pianko, Ed.	*Modern Methods of Testing Rotating Components of Turbomachines*, 46 pages, 1973.
168	C.Lengelle and C.Verdier	*Gas Sampling and Analysis in Combustion Phenomena*, 179 pages, 1973. French version AG 168 (Fr).
184	J.J.Bernard and J.Génot	*Radiation Cooling of Thrust Nozzles*, 68 pages, 1975. French version AG 184 (Fr).
185	J.H.Horlock and H.J.Perkins	*Annulus Wall Boundary Layers in Turbomachines*, 68 pages, 1975.
207	M.Pianko, Ed.	*Modern Methods of Testing Rotating Components of Turbomachines (Instrumentation)*, 190 pages, 1975.
208	A.Ferri, Ed.	*Improved Nozzle Testing Techniques in Transonic Flow*, 364 pages, 1975.
220	N.Scholz and A.Klein	*Aerodynamics of Cascades* (updating and translation of *Aerodynamik der Schaufelgitter*), 1977.
226	G.P.Russo, Ed.	A.Ferri's Selected Papers on *Advanced Design for Air Vehicles*, 1977.

6. THE AGARD PEP LECTURE SERIES PROGRAM

Since the inception of the AGARD Combustion Panel, Panel members and other experts have made extensive Panel-sponsored visits throughout the NATO community to present both formal and informal lectures and seminars. These activities were later broadened in scope to include many speakers on closely related topics. Since about 1960, the custom developed to present these formal, extensive lecture presentations at one or more locations and then to compile the lecture material in publications that were printed and distributed to select organizations and members. A listing of these lecture series is given in Table 6.1.

The lecture series dealt with important current problem areas and tended to be complementary to meetings and Working Groups. They have served the purpose of bringing essential background information to wide audiences and thereby provided an invaluable educational function. For example, the 200-page publication on *Airframe/Engine Interaction* (AGARD Lecture Series No.53) organized by A.Ferri contains lecture material presented in Dayton (Ohio), Toulouse, France, Munich (Germany), and London (UK) during June and July 1972. The contents of the lecture series are closely related and a useful introduction to AGARD Advisory Report No.36 on *Engine-Airplane Interference and Wall Corrections in Transonic Wind Tunnel Tests* (1971) as well as AGARD Advisory Report No.94 on *Improved Nozzle Testing Techniques in Transonic Flow* (1976).

* Early AGARD internal code: MIS 4.

TABLE 6.1

Lecture Series Sponsored by PEP and Organized by AGARD Plans and Programs

Lecture Series No.	*Subject, Location and Date*	*Director*	*Publication*
6	"Advances in Astronautical Propulsion"; Poltecnico di Milano and Varenna, Italy; September 1960	C.Casci	*Advances in Astronautical Propulsion*, Ed. C.Casci; Category I, Pergamon Press, Ltd., London 1962.
9	"Nuclear Rocket Propulsion"; University of Brussels, Belgium; November 1962	R.W.Bussard	AGARDograph 101 – *Nuclear Thermal and Electric Rocket Propulsion – Fundamentals, Systems and Applications*, Eds. R.A.Willaume, A.Jaumotte and R.W.Bussard; Category I, Gordon and Breach Science Publishers, New York, 1967.
13	"Nuclear, Thermal and Electric Rocket Propulsion"; University of Brussels, Belgium; September/October 1964		
15	"Fluid Mechanics in Radial Turbomachines, Von Kármán Institute, Rhôde-St-Genèse, Belgium; 1965	M.H.Vavra	No publication.
25	"Supersonic Turbomachines"; Varenna, Italy; May 1967	E.G.Johnson	AGARDograph 120 – *Supersonic Turbo-Jet Propulsion Systems and Components*, Ed. J.Chauvin; Category I, Technivision Services, Slough, England, 1969.
27	"Energy Sources for Aerospace Applications"; University of Brussels, Belgium; October 1967	G.C.Szego	AGARDograph 123 – *Space Power Systems*, Ed. G.C.Szego; Category II, printed by TER Ltd. in two volumes, London, 1969.
28	"Fluid Dynamics of Turbomachinery"	M.H.Vavra	No publication.
35	"Fluidic Control Systems for Aerospace Propulsion"; Brussels, Belgium, and Viareggio, Italy; September 1969	R.J.Reilly	AGARDograph 135 – *Fluidic Control Systems for Aerospace Propulsion*; Category II, printed by TER Ltd., London, 1969.
39	"Advanced Compressors"; Von Kármán Institute, Rhôde-St-Genèse, Belgium, and Bölkesjö, Norway; June 1970	J.Chauvin	Lecture Series 39 – *Advanced Compressors*; Category II, printed by TER Ltd., London 1970.
46	"Small Gas Turbines for Helicopters and Surface Transport"; Paris, France; London, UK; Montreal, Canada; and Pasadena, California, USA; June/July 1971	J.Fabri	Lecture Series 46 – *Small Gas Turbines for Helicopters and Surface Transport*; Category II, printed by TER Ltd., London, 1971.
53	"Airframe/Engine Integration"; Dayton, Ohio, USA; Toulouse, France; Munich, Germany; and London, UK; June/July 1972	A.Ferri	Lecture Series 53 – *Airframe/Engine Integration*; Category II, printed by TER Ltd., London, 1972.
72	"Distortion Induced Engine Instability"; London, UK; Wright-Patterson AFB, USA; and Naval Air Propulsion Test Center, USA; November 1974	A.E.Fuhs	Lecture Series 72 – *Distortion Induced Engine Instability*; Category II, printed by TER Ltd., London, 1974.

(Continued)

TABLE 6.1 (continued)

Lecture Series No.	*Subject, Location and Date*	*Director*	*Publication*
77	"Aircraft Engine Noise Generation, Emission, and Reduction"; Rhôde-St-Genèse (Belgium), DFVLR (West Germany), and Cranfield Institute of Technology (UK); June 1975	N.F.Rekos	Lecture Series 77 – *Aircraft Noise Generation, Emission and Reduction*; Category II, printed by TER Ltd., London, 1975.
83	"Modern Prediction Methods for Turbomachine Performance"; ONERA (France), DFVLR (Germany), Cranfield Institute of Technology (UK); June 1976	G.K.Serovy	Lecture Series 83 – *Modern Prediction Methods for Turbomachine Performance*; Category II, printed by TER Ltd., London, 1976.
90	"Laser Optical Measurement Methods for Aero Engine Research and Development"; Trenton (N.J., USA), London (UK), Urbino, (Italy); August/September 1977	H.B.Weyer	Lecture Series 90 – *Laser Optical Measurement Methods for Aero Engine Research and Development*, Category II, printed by TER Ltd., London, 1977.

The AGARD PEP lecture series program represents a valuable professional activity that is of highly educational value and should be continued. Unfortunately the termination of hard cover publications, mentioned earlier, has reduced the effectiveness of the program.

7. TECHNICAL EVALUATION AND ADVISORY REPORTS

The AGARD Consultant and Exchange Program has served to provide personal contacts between workers from different countries. The beneficial long-term effects of these exchanges may be difficult to document but these programs are certain to have contributed to technical and scientific advances in all the participating NATO countries. Some consultants have been commissioned to write Advisory Reports focussing on theoretical and experimental areas of activity in which additional work is required, both to further basic understanding and to advance the art of practical aerospace-propulsion development. Others have been commissioned to write Technical Evaluation Reports providing concise summaries of discussion or work highlights of particular PEP meetings. The authors of these reports have been well qualified to provide incisive criticism and to define programs for action. The technical evaluation and advisory reports may be recommended for their brevity as much as for their contents. They deserve a much wider circulation than they have received. In fact, a compendium of the AGARD PEP technical evaluation reports deserves a place on the shelves of any active researcher working in the fields of propulsion and energetics.

A summary of the PEP Advisory and Technical Evaluation Reports has been compiled in Table 7.1.

TABLE 7.1

AGARD PEP Advisory and Technical Evaluation Reports

Advisory Report No.	*Author(s)/Editor(s)*	*Title*	*Date*
3	A.Ferri	Gas Turbines (classified)	1966
20	A.Ferri, J.E.Bubb and T.Moulin, eds.	Air Breathing Missiles and their Military Interest (classified)	1970
22	W.R.Sears	Aircraft Engine Noise and Sonic Boom	1970
26	J.O.Powers and M.Pianko	Aircraft Engine Noise and Sonic Boom	1970
29	J.B.Esgar and R.A.Reynolds	High Temperature Turbines	1971
32	S.S.Penner and P.G.Atkinson	Reactions Between Gases and Solids	1971

(Continued)

TABLE 7.1 (continued)

Advisory Report No.	*Author(s)/Editor(s)*	*Title*	*Date*
36	A.Ferri, F.Jaarsma and R.Monti	Engine-Airplane Interference and Wall Corrections in Transonic Wind Tunnel Tests	1971
40	R.F.Sawyer	Atmospheric Pollution by Aircraft Engines and Fuels	1972
41	D.N.Bowditch and R.Monti	Inlets and Nozzles for Aerospace Engines	1972
44	R.B.White and L.Gardner	Aircraft Fuels, Lubricants, and Fire Safety	1972
50	R.H.Johnson, C.E.Oberly and R.E.Quigley, Jr	Energetics for Aircraft Auxiliary Power Systems	1972
63	P.A.Libby	Atmospheric Pollution by Aircraft Engines	1973
64	H.Grieb and N.A.Mitchell	V/STOL Propulsion Systems	1974
93	I.I.Pinkel	Future Fuels for Aviation	1976
94	F.Jaarsma	Improved Nozzle Testing Techniques in Transonic Flow	1976
101	H.Wittenberg	Engines for Small Propeller Driven RPVs	1977
101 S	H.Wittenberg	Engines for Small Propeller Driven RPVs (Classified Supplement)	1977
104	L.Giorgieri	Aero Engine Deterioration in Air Force Service	1977
104(FR)	L.Giorgieri	Détérioration des Moteurs d'Avions dans les Services des Armées de l'Air	1977
109	K.Papaliou	Technical Evaluation Report PEP 49th (A) Meeting. Secondary Flows in Turbomachines	1977
110	G.P.Sallee	Technical Evaluation Report PEP 49th (B) Meeting. Power Plant Reliability	1977

8. PEP WORKING GROUPS

Several most important contributions have been made in recent years by PEP Working Groups. Each comprises a small group of experts from the various nations who undertake a collaborative investigation and publish their results, usually as an AGARDograph or Advisory Report. These Working Groups were initiated in 1970 and major credit for their successful implementation must go to the late Antonio Ferri. The publications also identified problem areas and directions for future research. Useful contributions were made in the elimination of unnecessary duplication and in the standardization of test procedures.

An example of Working Group procedure is provided by AR-94 on *Improved Nozzle Testing Techniques in Transonic Flow* by F.Jaarsma. Nine organizations from five NATO countries joined PEP Working Group No.4 with A.Ferri as Chairman to study the indicated problem areas. Experimental work was performed in the participating laboratories during 1973 and 1974. Reports from the separate national groups were submitted in 1975 and compiled in AR-208, which was published in October 1975. Various model arrangments were tested for the purpose of studying inlet and nozzle performance and their interference with the airframe at selected laboratories, including 1 each in France, the UK, and the Netherlands, and 3 in Germany and in the US. All tests were carried out at a Mach number of 0.8 and over Reynolds number ranges from 13 to 20 x 10^6 (except that one of the US studies included values up to 170 x 10^6). The free-stream Mach numbers varied from 0.4 to 1.5. The following phenomena were investigated: boundary-layer blowing, tunnel blockage, nozzle coefficients, afterbody drag, cold vs hot jets, boundary layer control, jet spreading, Reynolds number effects, afterbody drag as related to forebody drag, boundary layer thickness, model support, and wall porosity. The data output is described in 15 original technical reports, which are briefly summarized in AR-94. Jaarsma includes in his report 12 recommendations on how experimental measurements should be performed, how data should be interpreted, and what additional work needs to be done. He concludes "that a multinational test program is possible and very profitable for the participating groups".

A summary of PEP Working Groups is given in Table 8.1. Clearly these Groups have proved to be valuable organizational tools in furthering PEP objectives and should therefore be continued.

TABLE 8.1
AGARD PEP Working Groups

WG No.	*Subject/Period of Activity*	*Leader*	*Publication/Remarks*
1	Aircraft Fire Safety	I.Glassman	CP 166, October 1975 WG initiated and prepared the Symposium held at Rome, Italy, 7–11 April 1975
2	Boundary Layer Effects in Turbomachines 1970–1972	J.Surugue	AG 164, December 1972 (joint PEP/FDP WG)
3	Modern Methods of Testing Rotating Components of Turbomachines 1970–1974	M.Pianko	AG 207, April 1975
4	Improved Nozzle Testing Techniques in Transonic Flow 1971–1974	A.Ferri	AG 208, October 1975 (joint PEP/FDP WG) AR 94, February 1976
5	Practical Numerical Computational Methods Applied to Turbomachines	M.Pianko	WG was cancelled in favor of NATO Advanced Study Institute
6	Propulsion and Power Supplies for Unmanned Vehicles 1974–1977	H.Wittenberg	AR 101 Vol.I, November 1977 Classified Suppl., November 1977 Vol.II (English), 1978 Classified Vol.II (French), 1978 Classified Vol.III, 1978 Classified
7	Future Aviation Fuels (Originally: Energy Crisis and Its Impact on Aviation Propulsion in the Future) 1974–1976	D.D.Weidhuner	AR 93, January 1976 (by I.I.Pinkel)
8	Engine Deterioration in Air Force Service 1974–1976	L.Giorgieri	AR 104 (English), August 1977 AR 104 (French), October 1977 Classified
9	Turbulent Transport Phenomena 1976–1978	M.Barrère	Report expected in 1978
10	Nozzle Testing Methodology	–	WG cancelled
11	Aircraft Fire Safety 1976–1978	I.Glassman	Report expected in 1978
12	Through Flow Calculations in Turbomachines 1977–1980	J.Chauvin	Report expected in 1980
13	Alternative Jet Engine Fuels 1979–1981	H.W.Johnson	
14	Suitable Averaging Techniques in Non-Uniform Internal Flows 1979–1981	F.Wazelt	

9. THE CURRENT AND FUTURE ROLES OF THE AGARD PEP

9.1 Current PEP Mission Objectives*

In a release from AGARD (PEP-236) dated November 2, 1976, the PEP terms of reference were described as follows:

"According to the AGARD mission, the Panel is continuously stimulating advances in its part of the aerospace field by cooperation, exchange, review, analysis, and recommendation of national research and development activities. Panel operations include individual consultant missions, multinational working groups, specialists' meetings, and wide scope symposia."

"The Panel is concerned with the various aerospace propulsion systems ranging from air-breathing engines to solid and liquid propellant rockets, as well as with auxiliary onboard power generation units including nuclear and electrical systems. The concern includes the necessary energy release and conversion processes".

* Terms of Reference and Topic Lists of AGARD Panels were revised in 1978 (AGARD-TOR-78). See Appendix III for revised form valid at time of printing.

"The activities of the Panel are twofold:

(1) Systems Performance and Application Approach
Mutual exchange between and cooperation of experts in the various related fields of science and technology is aimed towards engines with increased performance and reliability, their adaption to new or extended missions, engine vehicle integration, engine control, operation, maintenance, production, and cost effectiveness.

(2) Research and Development Approach
Exchange, cooperation and directory advice both in fundamental and applied research on thermodynamics, reaction kinetics, aerothermochemistry, plasma physics, fluid and gas dynamics, heat transfer, and engine-structure dynamics, as well as research and development in turbomachinery flow including secondary flows, boundary layers, and cooling, inlets and nozzles, transport phenomena in turbulent flow, combustion, fuels and lubricants; also high-strength, non-corrosive, and heat-resistant material application, engine integration, control and testing engines and components."

"Current and near term emphasis is given to airbreathing engines and the related fields, to small rocket propulsion, to fuels, and to basic combustion research".

While the description of mission objectives is adequately general, the actual distribution of PEP efforts has been heavily oriented toward improving the near-term aeronautical capabilities of the NATO countries.

9.2 Current PEP Topic List*

A November 1976 release from AGARD (PEP-236) provides the list of topics listed as items 7.1 through 7.13 (the numbering refers to AGARD/NATO listings) in Table 9.1. Again we find a listing of adequate scope which is, however, giving no indication of the relative emphasis placed on the different topics, which can be seen better by referring to the earlier Tables of activities and publications.

TABLE 9.1

PEP Topic List

7.1	THERMODYNAMICS AND COMBUSTION:
7.1.1	Fundamental research in high temperature reactions, aerothermochemistry, combustion and flames
7.1.2	Applied research in high temperature reactions, aerothermochemistry, combustion and flames
7.1.3	Fundamental and applied research on heat transfer (cooling of components, heat exchangers, etc.)
7.2	CHEMISTRY:
7.2.1	Fundamental research of interest to aerospace propulsion systems
7.2.2	Fundamental and applied research related to energy storage and conversion systems
7.3	PHYSICS, INCLUDING PLASMA PHYSICS:
7.3.1	Fundamental research related to aerospace propulsion systems
7.3.2	Fundamental research related to energy storage and conversion systems
7.4	AERODYNAMICS AND FLUID MECHANICS:
7.4.1	Fundamental research related to flow in inlets, ducts, turbomachinery and exhausts of aerospace propulsion systems and to flow problems with integrated vehicle/propulsion systems
7.4.2	Applied research related to flow inlets, ducts, turbomachinery and exhausts of aerospace propulsion systems and to flow problems with integrated vehicle/propulsion systems
7.4.3	Applied research related to flow through seals and passages, including air lubrication, air bearings and damped bearings
7.5	MATERIALS APPLICATIONS AND REQUIREMENTS:
7.5.1	Research related to application of various materials being used in aerospace propulsion systems, e.g., high-strength and light-weight metals and non-metallic compound materials, high-temperature and high-strength materials, heat-resistant alloys and ceramics, non-corrosive materials, anti-corrosive coatings.
7.5.2	Methods of fabrication and testing in view of materials applications in aerospace propulsion systems
7.6	AEROSPACE PROPULSION SYSTEMS – RESEARCH, DEVELOPMENT, PRODUCTION AND OPERATION ON THE FOLLOWING TYPES OF PROPULSION SYSTEMS:
7.6.1	Airbreathing engines
7.6.2	Liquid-propellant rockets
7.6.3	Solid-propellant rockets
7.6.4	Nuclear
7.6.5	Electric

(Continued)

* Terms of Reference and Topic Lists of AGARD Panels were revised in 1978 (AGARD-TOR-78) see Appendix III for revised form valid at time of printing.

TABLE 9.1 (continued)

7.7	PROPELLANTS, FUELS AND LUBRICANTS FOR THE FOLLOWING AEROSPACE PROPULSION SYSTEMS (INCLUDING CRYOGENICS):
7.7.1	Airbreathing engines
7.7.2	Liquid-propellant rockets
7.7.3	Solid-propellant rockets
7.7.4	Nuclear
7.7.5	Electric
7.8	AEROSPACE ENERGY CONVERSION SYSTEMS:
7.8.1	Static
7.8.2	Non-Static
7.9	CONTROL SYSTEMS FOR AEROSPACE PROPULSION AND ENERGY CONVERSION SYSTEMS:
7.9.1	Mechanical
7.9.2	Hydraulic
7.9.3	Electric
7.9.4	Fluidic
7.10	VEHICLE/PROPULSION SYSTEM INTEGRATION
7.11	TEST FACILITIES, INSTRUMENTATION, AND DATA PROCESSING:
7.11.1	Airbreathing aerospace-propulsion systems
7.11.2	Rocket-propulsion systems
7.11.3	Nuclear aerospace-propulsion systems
7.11.4	Electric aerospace-propulsion systems
7.11.5	Integrated vehicle/propulsion systems
7.12	ENVIRONMENTAL AND SAFETY ASPECTS:
7.12.1	Environmental pollution by aerospace propulsion systems
7.12.2	Noise pollution by aerospace propulsion systems
7.12.3	Safety problems, including fuel fire safety in aircraft
7.12.4	Vulnerability to damage (foreign objects; birds, etc.; combat)
7.13	ENGINEERING:
7.13.1	Fundamental and applied research in the mechanical aspects of aerospace propulsion systems
7.13.2	Research into the reduction of life-cycle costs of aerospace propulsion systems

9.3 Recent and Planned Future Activities

Table 9.2 indicates some recent and planned future activities for some of which Panel publications are not yet available. It is apparent from the nature of these activities that current PEP efforts remain closely related to the NATO military needs in aeronautical engineering. The short-term impact of these studies on military planning and development is no doubt beneficial and effective. One might, however, wish that the well motivated emphasis on near-term practical needs were accompanied by more longer range studies such as the planned PEP work on energy conservation in aircraft propulsion, which will ultimately exert a profound effect on the complexion of NATO military efforts.

TABLE 9.2

Recent and Planned Future PEP Activities for which Publications will Become Available in the Future

Panel Meeting	*Location*	*Activities and Publication(s)*
49th, March/April 1977	The Hague Netherlands	Two Specialists Meetings (A) Program Committee Chairman: J.Fabri AGARD Conference Proceedings 214 – *Secondary Flows in Turbomachines*, Category II, 1977, and AGARD Advisory Report 109, Category II, 1977. (B) Program Committee Chairman: J.C.Ripoll AGARD Conference Proceedings 215 – *Power Plant Reliability*, Category II, 1977, and AGARD Advisory Report 110, Category II, 1977.

(Continued)

TABLE 9.2 (continued)

50th, September 1977	Ankara, Turkey	Program Committee Chairman: D.K.Hennecke AGARD Conference Proceedings 229 – *High Temperature Problems in Gas Turbine Engines*, Category II, 1977, and AG AGARD Advisory Report 116, Category II, 1977.
51st, April 1978	London, UK	Two Specialists Meetings (A) Program Committee Chairman: J.Dunham AGARD Conference Proceedings 236 – *Icing Testing for Aircraft Engines* (B) Program Committee Chairman: E.E.Covert AGARD Conference Proceedings 237 – *Seal Technology in Gas Turbine Engines*
52nd, October 1978	Cleveland, Ohio USA	Program Committee Chairman: J.Acurio AGARD Conference Proceedings 248 – *Stresses, Vibrations, Structural Integration and Engine Integrity*
PEP activities in 1978 will include Working Groups on aircraft fire safety, and on fundamental research in turbulent transport phenomena. A Lecture Series is being organized for the fall on energy conservation in aircraft propulsion.		

9.4 Recommendations for Future Activities

A primary problem concerning PEP activities is the lack of visibility of Panel plans and programs, which are unknown to many active workers in the fields covered by PEP. Panel agenda and publications are not sufficiently publicized. As attendance at meetings is by invitation from Panel Members, access is effectively restricted in some countries. It is therefore recommended that:

(i) A much wider distribution be implemented of Category II publications in order to assure access to these important papers by the interested scientific and engineering communities.

(ii) A similarly augmented distribution be especially made also for the technical evaluation and advisory reports.

(iii) Wider access be provided to PEP meetings and wider publicity should be given to PEP meetings, in general. These objectives may perhaps be best accomplished by seeking publicity outlets in such established publications as Aeronautics and Astronautics in the US and comparable publications in other NATO countries. Correspondingly, PEP Members should solicit larger representations from their own countries than has been customary in the past.

Interpanel activities (involving, for example, the PEP and the Fluid Dynamics Panel) have been organized occasionally in the past and have led to fruitful interdisciplinary exchanges. It is recommended that:

(iv) Activities of major scope take advantage more frequently than in the past of the talents and diversified interests of members who are associated with different AGARD Panels.

The relation between the AGARD Panels and the NATO Science Office may profitably be re-examined. The activities of the NATO Science Summer Schools might, on occasion, encompass areas of activity for which the PEP has primary responsibility. It is recommended that:

(v) Summer Schools be considered on one or more of the PEP topics.

As regards the topics considered by the Panel, it is noted that two important advances in combustion research have occurred since the antecedent to the PEP played a dominant role in this type of research. These are the development of numerical techniques to utilize the full capacity of high speed computing machines in the quantitative description of the complex flow fields existing within rocket-engine and turbine combustion chambers, as well as within internal combustion engines used in transportation vehicles; the development of powerful new diagnostic tools (e.g. laser-scattering methods which allow measurements with high temporal and spatial resolution of species compositions, temperatures, densities, particle-size distributions, velocity components, and pressures. The engineers and scientists who are developing the numerical and diagnostic tools are not communicating effectively with each other. It is a major challenge to coordinate advances in these two disparate fields for the purpose of assuring that the flow field modelers will ultimately make defensible and believable constructions. It is recommended that:

(vi) The task of coordinating advances in these aspects of combustion research be given increased emphasis.

Vigilant maintenance of viable NATO defenses does not concern exclusively the military needs of the community. A secure region can be built and maintained only if a prosperous and economically sound community of nations exists. It is therefore recommended that:

(vii) Systems studies relating to NATO energy planning for both civilian and military purposes be started. More detailed suggestions are made in Appendix II.

This recommendation for broadening the scope of PEP topical areas should not be interpreted to be a criticism of current or past Panel activities. There is, in fact, no question that Panel involvement in such immediately useful programs as helicopter propulsion systems, STOL aircraft development, improved turbines with higher temperature duty cycles, materials compatibility studies, advanced propellants, etc. remain both timely and appropriate. It is recommended that:

(viii) Panel activities in immediately useful programs be vigorously continued.

Problems may arise in accommodating the broad scope of PEP activities within the limits of expertise of presently existing or prospective new Panel memberships. It appears to be both inefficient and undesirable to increase Panel membership beyond presently existing levels. It is therefore recommended that:

(ix) Increased use be made of Working Groups to assure adequate topical coverage by enrolling the assistance of competent specialists wherever they may be found within the NATO countries. Particular suggestions are made in Appendix II.

9.5 CONCLUSIONS

The beginnings of AGARD and of the PEP relate to times of crisis in Europe. The PEP was born with a mission: to contribute to the resolution of important problems associated with the rebirth and expansion of the aeronautical sciences in the NATO countries. The methodology was dictated by the purposes of the Marshal plan: To use the best talents in the NATO community for the common good until the best could be found everywhere in the NATO countries. Significant progress has been made in realizing this ambitious goal in combustion studies, rocket propulsion development, advanced aircraft designs, helicopter construction, STOL and VSTOL aircraft development, advanced missile systems for the defense of Western Europe, etc. Important supporting scientific and engineering studies aimed at these objectives are now being pursued in many countries. Economic factors, market availabilities, and capital-investment limitations have precluded equal penetration of advanced technologies throughout the NATO community. But significant contributions are nevertheless made in some important areas by nearly all of the member countries.

Panel Members who responded to a query concerning their estimation of PEP effectiveness in recent years generally concur with the view expressed by R.A.Reynolds (Canada), that "PEP was the most effective organization in transferring and exchanging technological information" with which they have been associated. This conclusion is, in large measure, the result of the fact that PEP meeting attendance involved participation by investigators from different disciplines who would not normally meet, that generally an adequate archival literature did not exist for the agenda items, and that there were urgently important problems which required resolution and interfaced with meeting topics.

So the scientific exchange programs, conferences, and synthetic studies advanced by the PEP continues to play an important role. They have necessarily lost the *unique* impact which they had during the fifties because sophisticated work became the rule rather than the exception and because parallel roles of increasing importance and sophistication are being played by national, regional and international societies. Is it then appropriate to curtail the mission of AGARD and of the PEP?

I believe the answer should be emphatically "no" to the rhetorical question posed. The PEP at its beginnings was assigned a dominant function in interdisciplinary research relating to the aeronautical activities of the NATO community. With this primary definition as a working guide, there will always be new problems that merit dedicated effort for the advancement of the aerospace sciences. Above all, the AGARD mission, in general, and the PEP functions, in particular, remain of importance to the security of the NATO alliance and must be continued until detente becomes as successful as we all hope it will be.

ACKNOWLEDGEMENTS

The author is greatly indebted to Joachim H.Krengel, Executive Officer of the AGARD Propulsion and Energetics Panel, for supplying extensive background information which has been used freely in the preparation of this report. The author is also indebted to the following Panel Members for furnishing careful evaluations of past Panel activities and of proposed future programs: C.Casci, J.Dunham, I.Glassman, A.Jaumotte, A.H.Lefebvre, R.A.Reynolds, R.Monti, and N.F.Rekos. Helpful discussions are gratefully acknowledged with P.A.Libby and F.E.Marble. The author is indebted to Mrs Kay Hutcheson for preparing successive versions of this manuscript with unusual efficiency.

APPENDIX 1

PANEL MEMBERSHIP AND OFFICERS (1952–1977)
PART I – MEMBERS*

BELGIUM		
J.Chauvin	Von Kármán Institute for Fluid Dynamics, Rhôde-St-Genèse	March 1968 to date
J.Ducarme (Chairman 1956–58)	Institut de Mécanique, Université de Liège	September 1952 to date (Founder Member)
P.Godfrind	Ecole Royale Militaire, Bruxelles	April to July 1961
C.Hirsch	Dept. de Mécanique des Fluides, Vrije University, Bruxelles	January 1977 to date
R.Jacques	Ecole Royale Militaire, Bruxelles	January 1971 to date
A.Jaumotte	Institut de Mécanique Appliqué, Université Libre de Bruxelles	April 1958 to date
E.Tits	Laboratoire de Chimie Appliquée, Ecole Royale Militaire, Bruxelles	July 1961 to date
CANADA		
M.Brennan	Defence Research Board and later Canadian Transport Commission, Ottawa	July 1966 to December 1970
J.W.Broughton	National Research Council, Ottawa	September 1952 to February 1964 (Founder Member)
W.G.Brownlee	Canadian Armament R & D Establishment, Quebec	October 1968 to January 1970
I.R.Cameron	Canadian Armament R & D Establishment, Quebec	July 1960 to October 1968
D.H.E.Cross	Defence Research Board and later Department of Industry, Ottawa	March 1964 to March 1969
R.A.Reynolds	Department of Industry, Ottawa	March 1969 to December 1976
R.Sandri	National Research Council, Ottawa	March 1964 to March 1969
R.B.Whyte	Fuels and Lubricants Laboratory, Division of Mechanical Engineering, National Research Council, Ottawa	March 1964 to date
R.F.Wilkinson	Canadian Armament R & D Establishment, Quebec	January 1959 to July 1960
DENMARK		
B.Qvale	Laboratoriet for Energiteknik, Polytekniske Laereanstalt, Lyngby	October 1971 to date
K.Refslund	Technical University, Lyngby	September 1955 to November 1972
FRANCE		
M.L.Barrère	ONERA, Châtillon-sous-Bagneux	June 1969 to date
P.B.Bétin	Direction Technique des Engins, Paris	June to December 1969
G.Casandjian	Service Technique Aeronautique, Paris	January 1976 to March 1976
J.F.Chevalier	SNECMA, Centre d'Essais de Villaroche, Moisy-Cramayel	June 1969 to date
P.Colombani	SNECMA, Paris and later Blanquefort	July 1961 to June 1969
R.Dubarry-Barbe	Centre d'Essais des Propulseurs, Saclay, Orsay	April 1963 to June 1965
J.Fabri (Chairman 1961–63)	ONERA, Châtillon-sous-Bagneux	September 1952 to December 1969 January 1975 to date (Founder Member)
A.Journeau	DRME, Paris	March 1973 to date
J.Lamy	Centre d'Essais des Moteurs et Hélices, Saclay	September 1952 to November 1954 (Founder Member)

* 1977 Members underlined.

G.Monnot	Direction des Recherches et Moyens d'Essais, Paris	January 1972 to March 1973
M.Pianko (Chairman 1975–77)	ONERA, Châtillon-sous-Bagneux	June 1965 to date
J.C.Ripoll	Centre d'Essais des Propulseurs, Saclay, Orsay	January 1972 to date
P.R.M.Soufflet	Centre d'Essais des Moteurs et Hélices, Saclay	April 1959 to April 1963
J.Surugue (Chairman 1952–54)	ONERA, Châtillon-sous-Bagneux	September 1952 to December 1974 (Founder Member)
A.Vialette	Service Technique Aéronautique, Paris	November 1954 to April 1959
GERMANY		
W.Dettmering	Mitglied des Vorstandes der Friedr. Krupp GmbH, Essen	May 1969 to December 1977
D.K.Hennecke	Motoren und Turbinen Union GmbH, München	January 1975 to date
W.Jost	University of Göttingen, Göttingen	October 1955 to August 1963
O.Lutz (Chairman 1963–65)	Technical University and DFVLR, Braunschweig	October 1955 to September 1971
P.Ruden	Industrieanlagen-Betriebsgesellschaft GmbH, München	June 1957 to December 1969
N.K.H.Scholz	MTU München GmbH and Technical University of München	June 1970 to September 1974
H.G.Wagner	University of Göttingen, Göttingen	April 1962 to May 1969
F.Wazelt	Lehrstuhl für Flugantriebe, Technische Hochschule Darmstadt, Darmstadt	January 1975 to date
G.Winterfeld (Chairman 1977 to date)	DFVLR, Institut für Antriebstechnik, Köln	January 1972 to date
GREECE		
A.Achtidas	30th Air Materiel Command, Elefsis Air Base	March to October 1970; January 1975 to date
T.Houlis	Holargos, Athens	September 1958 to March 1970
A.Lambrou	State Armament Factory, Old Phaleron, Athens	November 1954 to March 1970
A.Pavlidis	State Aircraft Factory, Old Phaleron, Athens, and later 30th Air Materiel Command, Paleon Phaleron, Athens	October 1970 to March 1976
C.Sotiropoulos	RDD, Air Force Command, Holargos, Athens	March 1970 to December 1971
ITALY		
G.Bussi	Politecnico di Torino, Torino	February 1976 to date
C.Capetti	CNPM, Politecnico di Milano, Milano	February 1953 to June 1970
C.Casci (Chairman 1965–67)	Politecnico di Milano, Istituto di Macchine, Milano	March 1959 to date
D.Dini	Istituto di Macchine, Università degli Studi, Pisa	January 1966 to date
L.Giorgieri	Ministero della Difesa Aeronautica, Roma	June 1964 to date
E.Macioce	Ministero della Difesa Aeronautica, Roma	March 1959 to June 1964
E.Mancini	FIAT, Torino	September 1952 to 1953 (Founder Member)
G.Maoli	FIAT-Divisione Aviazione, Direzione Progettazione, Torino	October 1962 to date
R.Monti	Istituto di Aerodinamica, Università degli Studi, Napoli	June 1967 to date
G.Salvatore	Università di Roma, Roma	June 1966 to December 1974
M.Sirinian	Centro Consultivo Studi e Ricerche Aeronautica Militare, Roma	January 1975 to date

NETHERLANDS		
W.J.Basting	NLR, Amsterdam	May 1957 to June 1960
N.Feis	NLR, Amsterdam	July 1960 to March 1967
F.Jaarsma (Chairman 1973–75)	Duits-Nederlandse Windtunnel, Post Emmeloord	April 1967 to December 1977
H.Wittenberg	Department of Aeronautical Engineering, Delft Technical University	January 1973 to date
G.Zwikker	NLR, Amsterdam	December 1952 to April 1957
NORWAY		
O.Blichner	Norwegian Defence Research Establishment, Kjeller	September 1953 to January 1960
L.Harang	NDRE, Kjeller	December 1952 to 1953
S.E.Høst	NDRE, Kjeller	January 1970 to March 1975
R.Hveding	NDRE, Kjeller	September to November 1952 (Founder Member)
G.Kristofersen	NDRE, Kjeller	April 1975 to date
T.Krog	NDRE, Kjeller	February 1960 to December 1972
R.J.Mowill	Kongsberg Vapenfabrikk, Kongsberg	January 1969 to December 1972
R.E.Stanley	Kongsberg Vapenfabrikk, Kongsberg	January 1973 to October 1975
S.Strøm	Kongsberg Vapenfabrikk, Kongsberg	January 1976 to date
TURKEY		
F.Aydin Makina	Hava Ikmal Bakim Merkezi, Eskişehir	January 1974 to date
K.Büyümihci	TBTAK, Ankara	January 1977 to December 1977
N.Eraslan	University of Istanbul, Istanbul	July 1960 to July 1964
E.Inger	TBTAK, Ankara	January 1977 to December 1977
I.Keskin	Turkish Air Force, Kayseri	August 1967 to August 1972
H.Sezgen	Mak. Müh. Bölümü, Orta Doğu Teknik Üniversitesi, Ankara	August 1964 to April 1977
O.Tüzünalp	Türkiye Bilimsel ve Teknik Araştırma Kurumu, Ankara	August 1972 to date
UNITED KINGDOM		
E.G.D.Andrews	Bristol Siddeley Engines, Ltd.; later Rolls-Royce, Ltd., Coventry	August 1966 to December 1968
A.D.Baxter	De Havilland Engine Co., Ltd., Hatfield	August 1957 to July 1960
F.J.Bayley	Applied Science Laboratory, The University of Sussex, Falmer, Brighton	April 1976 to date
D.I.Dawton	National Gas Turbine Establishment, Pyestock	March 1967 to January 1971
J.Dunham	National Gas Turbine Establishment, Pyestock	January 1971 to date
J.E.P.Dunning	Rocket Propulsion Department, Royal Aircraft Establishment, Westcott	August 1957 to June 1959
R.P.Hagerty	Rocket Propulsion Establishment, Royal Aircraft Establishment, Westcott	June 1959 to March 1967
C.T.Hewson (Chairman 1969–71)	Rolls-Royce, Ltd., Derby	August 1966 to May 1971
A.J.B.Jackson	Rolls-Royce, Ltd., Aero Engine Division, Derby	February 1975 to date
R.R.Jamison	Bristol Siddeley Engines, Ltd., Bristol	August 1960 to August 1966
R.J.Lane	Rolls-Royce (1971), Ltd., Bristol Engine Division Bristol	March 1969 to February 1975
A.H.Lefebvre	Rolls-Royce, Ltd., Derby; later Cranfield Institute of Technology, Bedford	August 1957 to April 1961 January 1972 to April 1976

B.P.Mullins (Chairman 1954–56)	National Gas Turbine Establishment, Pyestock	September 1952 to August 1957 (Founder Member)
W.G.S.Parker	Rocket Propulsion Department, Royal Aircraft Establishment, Westcott	January 1955 to August 1957
UNITED STATES		
J.Acurio	US Army Air Mobility and Development Laboratory, Cleveland, Ohio	November 1975 to date
R.T.Alpaugh	Department of the Army, Washington, D.C.	March 1971 to September 1973
P.G.Atkinson, Jr.	Aerospace Research Lab., Wright-Patterson AFB, Dayton, Ohio; later Directorate of Laboratories, Andrews AFB, Maryland	March 1964 to July 1971
E.E.Covert	Department of Aeronautics and Astronautics, Massachusetts Institute of Technology, Cambridge, Massachusetts	August 1976 to date
F.E.C.Culick	California Institute of Technology, Pasadena, California	October 1976 to date
A.Ferri (Chairman 1967–69)	Polytechnic Institute of Brooklyn; later New York University	April 1957 to December 1975
A.E.Fuhs	Naval Postgraduate School, Monterey, California	February 1969 to December 1977
M.Gerstein	NACA, Cleveland, and later National Engineering Science Co. and Dynamics Science Corp., Pasadena, California	June 1954 to May 1964
I.Glassman (Chairman 1971–73)	Princeton University, Princeton, New Jersey	July 1964 to date
C.B Hargis, Jr	Department of the Air Force, Washington, D.C.	July 1971 to September 1974
E.G.Johnson	Aerospace Research Laboratories, Wright-Patterson AFB, Ohio	January 1972 to December 1975
F.E.Marble	California Institute of Technology, Pasadena, California	September 1952 to May 1964 (Founder Member)
J.G.Mitchell	Directorate of Technology, HQs Arnold Engineering Development Center, Arnold AF Station, Tennessee	October 1976 to date
T.F.Nagey	General Motors Corp., Allison Division, and later GM Technical Center, Warren, Michigan	February 1962 to December 1970
H. von Ohain	Aerospace Research Laboratory, Wright-Patterson AFB, Ohio	January 1966 to December 1971
S.S.Penner (Chairman 1958–61)	California Institute of Technology; Institute for Defense Analysis; and later University of California, San Diego, La Jolla, California	September 1952 to December 1968 (Founder Member)
N.F.Rekos	Office of Aeronautics and Space Technology, NASA, Washington, D.C.	May 1968 to December 1977
A.M.Rothrock	NACA, later NASA, Washington, D.C.	December 1956 to May 1964
E.C.Simpson	AF Aero Propulsion Lab., Wright-Patterson AFB, Dayton, Ohio	July 1971 to December 1977
D.D.Weidhuner	Department of the Army, Washington, D.C., and later, Alexandria, Virginia	April 1961 to June 1968; October 1973 to September 1976
A.J.Wennerstrom	Engine Turbine Division, Air Force Aero-Propulsion Lab., Wright-Patterson AFB, Dayton, Ohio	May 1976 to date

PART II – OFFICERS

Period	*Chairman*	*Deputy Chairman*	*Elected at*
1952–1954	J.Surugue	B.P.Mullins	2nd Meeting, December 1952
1954–1956	B.P.Mullins	J.Ducarme	7th Meeting, November 1954
1956–1958	J.Ducarme	S.S.Penner	11th Meeting, December 1956
1958–1961	S.S.Penner	J.Fabri	14th Meeting, October 1958
1961–1963	J.Fabri	O.Lutz	19th Meeting, March 1961
1963–1965	O.Lutz	C.Casci	21st Meeting, April 1963
1965–1967	C.Casci	A.Ferri	25th Meeting, April 1965
1967–1969	A.Ferri	C.T.Hewson	29th Meeting, June 1967
1969–1971	C.T.Hewson	J.Chauvin (1969–1970) I.Glassman (1970–1971)	33rd Meeting, May 1969 36th Meeting, September 1970
1971–1973	I.Glassman	F.Jaarsma	37th Meeting, May 1971
1973–1975	F.Jaarsma	M.Pianko	41st Meeting, April 1973
1975–1977	M.Pianko	G.Winterfeld	45th Meeting, April 1975
1977–	G.Winterfeld	J.Dunham	49th Meeting, March 1977

Period	*Executive*
1952–1953	G.D.Colchagoff, USAF
1953–1956	K.W.Baker, USAF
1956–1960	R.M.Horridge, USAF
1960–1963	F.F.Hart, USAF
1963	E.A.Robie, USN
1963–1964	F.J.Readdy, USN
1964–1967 (Mar)	C.Lupold, FAF
April 1967–July 1972	R.P.Hagerty, UK (MOD)
July 1972–June 1976	J.B.Catiller, USAF
July 1976–to date	J.H.Krengel, GE (DFVLR)

APPENDIX II

SOME SUGGESTIONS FOR SYSTEMS STUDIES RELATED TO NATO ENERGY PLANNING

With regard to the future of the energy supply of the NATO countries the following questions can be posed:

(i) Which ones among the host of developing energy technologies are best adapted to the NATO community and what is a desirable manner for their implementation?

(ii) How should NATO resources be apportioned both within and outside the community?

(iii) Is it possible to develop a coordinated NATO resource-management plan with optimal import and export allocations? What are appropriate regional energy-conservation measures relating to aeronautical systems?

(iv) Over the intermediate term, we require stockpiles of liquid and gaseous fuels especially for the use of the NATO air forces. Where should these be, what should they be, how should they be maintained and paid for, and what are the technical problems associated with these long-term program goals? Should there be NATO petroleum reserves in the North Sea, reserved oil shale deposits in Colorado (US), allocated and protected fields of natural gas?

(v) Are the energy technologies preferred on economic grounds compatible with NATO planning in aeronautics? Can we contemplate aircraft that are not powered by turbine or rocket engines? What are the implications of cheap and readily available electrical energy (derived, for example, from solar-energy farms, nuclear breeder reactors, fusion reactors, solar-satellite power stations, etc) on the preferred make-up of ground-based and air borne transportation systems?

The author suggests that studies on these questions be performed within the NATO community. Resulting from these studies direct measures will ensure the future of aeronautics to the benefit of all NATO countries.

APPENDIX III

PROPULSION AND ENERGETICS PANEL (PEP)

TERMS OF REFERENCE

The Panel is concerned with all aspects of aerospace propulsion systems like airbreathing engines, including auxiliary on-board power generation units, solid and liquid propellant rockets, and nuclear and electrical systems. The concern includes the necessary energy release and conversion processes. In the field of gas turbines interest is extended beyond aerospace application to naval and land vehicle propulsion.

Specifically, the following subjects are covered:

- Combustion and Fuels, including the pertinent parts of fluid dynamics like turbulent mixing, chemistry, particularly reaction kinetics, and thermodynamics. Fuels and lubricants as used in airbreathing engines and propellants employed in rockets are covered as well.
- Fluid and Gas Dynamics, focussing on internal flows as envisaged in the components of turbine engines: inlets, compressors, combustors, turbines, afterburners and nozzles, including through flows in steady, transient and unsteady states, secondary flows, boundary layers, turbulent transport and heat transfer phenomena, external losses, aeroelasticity and noise.
- Engineering of Aerospace Propulsion Systems, comprising the design, development, operation and maintenance of these systems, including mission analysis and requirements, selection of cycles, analysis of loads, stresses, vibrations, and transient thermal effects, materials application and requirements, environmental aspects like noise and pollution, life cycle and maintenance costs, engine control, reliability, and integration.
- Propulsion Test Facilities and Relevant Measurement Techniques, including the development of new measuring systems and of test facilities which are capable of simulating up to actual environmental conditions, both for complete engines and for components, and which allow testing of typical cycles of engine operation.

The Propulsion and Energetics Panel coordinates with the other AGARD Panels and assists more frequently FMP, FDP, and SMP, both in Technical Meetings and in Working Groups.

PROPULSION AND ENERGETICS PANEL

TOPICS LIST

Code No.7

7.1 Thermodynamics and Combustion
- 7.1.1 Fundamental research in high-temperature reactions, aerothermochemistry, combustion and flames
- 7.1.2 Applied research in high-temperature reactions, aerothermochemistry, combustion and flames
- 7.1.3 Fundamental and applied research into heat transfer (cooling of components; heat exchangers, etc.)

7.2 Chemistry
- 7.2.1 Fundamental research of interest to aerospace propulsion systems
- 7.2.2 Fundamental and applied research related to energy storage and conversion systems

7.3 Physics, Including Plasma Physics
- 7.3.1 Fundamental research related to aerospace propulsion systems
- 7.3.2 Fundamental research related to energy storage and conversion systems

7.4 Aerodynamics and Fluid Mechanics
- 7.4.1 Fundamental research related to flow in inlets, ducts, turbomachinery and exhausts of aerospace propulsion systems and to flow problems with integrated vehicle/propulsion systems
- 7.4.2 Applied research related to flow in inlets, ducts, turbomachinery and exhausts of aerospace propulsion systems and to flow problems with integrated vehicle/propulsion systems
- 7.4.3 Applied research related to flow through seals and passages, including air lubrication, air bearings and damped bearings.

7.5 Materials Applications and Requirements
- 7.5.1 Research related to application of various materials being used in aerospace propulsion systems, e.g.:
  - high-strength, light-weight materials and non-metallic compound materials
  - high-temperature, high-strength materials
  - heat resistant alloys and ceramics
  - non-corrosive materials
  - anti-corrosive coatings
- 7.5.2 Methods of fabrication and test in view of materials applications in aerospace propulsion systems

7.6 Aerospace Propulsion Systems – Research, Development, Production and Operation
- 7.6.1 Airbreathing
- 7.6.2 Liquid Propellant Rocket
- 7.6.3 Solid Propellant Rocket
- 7.6.4 Nuclear
- 7.6.5 Electric

7.7 Propellants, Fuels and Lubricants for Aerospace Propulsion (Including Cryogenics)
- 7.7.1 Airbreathing
- 7.7.2 Liquid Propellant Rocket
- 7.7.3 Solid Propellant Rocket
- 7.7.4 Nuclear
- 7.7.5 Electric

7.8 Aerospace Energy Conversion Systems
- 7.8.1 Static
- 7.8.2 Non-Static

7.9 Control Systems for Aerospace Propulsion and Energy Conversion Systems
- 7.9.1 Mechanical
- 7.9.2 Hydraulic
- 7.9.3 Electric
- 7.9.4 Fluidic

7.10 Vehicle/Propulsion System Integration

7.11 Propulsion Test Facilities, Instrumentation, and Data Processing
- 7.11.1 Airbreathing Aerospace Propulsion Systems
- 7.11.2 Rocket Propulsion Systems
- 7.11.3 Nuclear Aerospace Propulsion Systems
- 7.11.4 Electric Aerospace Propulsion Systems
- 7.11.5 Integrated Vehicle/Propulsion Systems

7.12 Environmental and Safety Aspects
- 7.12.1 Environmental Pollution by Aerospace Propulsion Systems
- 7.12.2 Noise Pollution by Aerospace Propulsion Systems
- 7.12.3 Safety Problems, Including Fuel Fire Safety in Aircraft
- 7.12.4 Vulnerability to Damage (Foreign Objects, Birds, etc.; Combat)

7.13 Engineering
- 7.13.1 Fundamental and Applied Research in Mechanical Aspects of Aerospace Propulsion Systems
- 7.13.2 Research Into Reduction of Life-Cycle Costs of Aerospace Propulsion Systems

REPORT DOCUMENTATION PAGE

1. Recipient's Reference	2. Originator's Reference	3. Further Reference	4. Security Classification of Document
	AGARD-AR-111	ISBN 92-835-1258-8	UNCLASSIFIED

5. Originator Advisory Group for Aerospace Research and Development
North Atlantic Treaty Organization
7 rue Ancelle, 92200 Neuilly sur Seine, France

6. Title

THE AGARD PROPULSION AND ENERGETICS PANEL: 1952–1977

7. Presented at

8. Author(s)

S.S.Penner

9. Date

November 1978

10. Author's Address Energy Center and Department of
Applied Mechanics and Engineering Sciences
University of California, San Diego, La Jolla, Calif.92093

11. Pages

34

12. Distribution Statement This document is distributed in accordance with AGARD policies and regulations, which are outlined on the Outside Back Covers of all AGARD publications.

13. Keywords/Descriptors

Propulsion	Reviews	Technical societies
Energy	Combustion	Documents
Research	Information centers	Publicity

14. Abstract

This Advisory Report summarizes the work done during the past 25 years by the AGARD Propulsion and Energetics Panel formerly named Combustion and Propulsion Panel, and initially, Combustion Panel. It analyses the adaptation of the Panel to new challenging demands of propulsion technology and the impact of Panel activities on Research and Development within NATO countries. Based on this survey and his experience, the author proposes again a move in future Panel activities, particularly long term emphasis of energy related topics. In addition, proposals on AGARD publication and publicity policy are included.

Prepared for the Propulsion and Energetics Panel of AGARD.

AGARD Advisory Report No.111
Advisory Group for Aerospace Research and Development, NATO
THE AGARD PROPULSION AND ENERGETICS PANEL: 1952–1977
S.S.Penner
Published November 1978
34 pages

This Advisory Report summarizes the work done during the past 25 years by the AGARD Propulsion and Energetics Panel formerly named Combustion and Propulsion Panel, and initially, Combustion Panel. It analyses the adaptation of the Panel to new challenging demands of propulsion technology and the impact of Panel activities on Research and

P.T.O.

AGARD-AR-111

Propulsion
Energy
Research
Reviews
Combustion
Information centers
Technical societies
Documents
Publicity

AGARD Advisory Report No.111
Advisory Group for Aerospace Research and Development, NATO
THE AGARD PROPULSION AND ENERGETICS PANEL: 1952–1977
S.S.Penner
Published November 1978
34 pages

This Advisory Report summarizes the work done during the past 25 years by the AGARD Propulsion and Energetics Panel formerly named Combustion and Propulsion Panel, and initially, Combustion Panel. It analyses the adaptation of the Panel to new challenging demands of propulsion technology and the impact of Panel activities on Research and

P.T.O.

AGARD-AR-111

Propulsion
Energy
Research
Reviews
Combustion
Information centers
Technical societies
Documents
Publicity

AGARD Advisory Report No.111
Advisory Group for Aerospace Research and Development, NATO
THE AGARD PROPULSION AND ENERGETICS PANEL: 1952–1977
S.S.Penner
Published November 1978
34 pages

This Advisory Report summarizes the work done during the past 25 years by the AGARD Propulsion and Energetics Panel formerly named Combustion and Propulsion Panel, and initially, Combustion Panel. It analyses the adaptation of the Panel to new challenging demands of propulsion technology and the impact of Panel activities on Research and

P.T.O.

AGARD-AR-111

Propulsion
Energy
Research
Reviews
Combustion
Information centers
Technical societies
Documents
Publicity

AGARD Advisory Report No.111
Advisory Group for Aerospace Research and Development, NATO
THE AGARD PROPULSION AND ENERGETICS PANEL: 1952–1977
S.S.Penner
Published November 1978
34 pages

This Advisory Report summarizes the work done during the past 25 years by the AGARD Propulsion and Energetics Panel formerly named Combustion and Propulsion Panel, and initially, Combustion Panel. It analyses the adaptation of the Panel to new challenging demands of propulsion technology and the impact of Panel activities on Research and

P.T.O.

AGARD-AR-111

Propulsion
Energy
Research
Reviews
Combustion
Information centers
Technical societies
Documents
Publicity

Development within NATO countries. Based on this survey and his experience, the author proposes again a move in future Panel activities, particulary long term emphasis of energy related topics. In addition, proposals on AGARD publication and publicity policy are included.

Prepared for the Propulsion and Energetics Panel of AGARD.

ISBN 92-835-1258-8

Development within NATO countries. Based on this survey and his experience, the author proposes again a move in future Panel activities, particulary long term emphasis of energy related topics. In addition, proposals on AGARD publication and publicity policy are included.

Prepared for the Propulsion and Energetics Panel of AGARD.

ISBN 92-835-1258-8

Development within NATO countries. Based on this survey and his experience, the author proposes again a move in future Panel activities, particulary long term emphasis of energy related topics. In addition, proposals on AGARD publication and publicity policy are included.

Prepared for the Propulsion and Energetics Panel of AGARD.

ISBN 92-835-1258-8

Development within NATO countries. Based on this survey and his experience, the author proposes again a move in future Panel activities, particulary long term emphasis of energy related topics. In addition, proposals on AGARD publication and publicity policy are included.

Prepared for the Propulsion and Energetics Panel of AGARD.

ISBN 92-835-1258-8